SIGMA XI QUARTERLY

Vol. XVI MARCH, 1928 No. 1

CONVENTION NUMBER

President Little on Research in Genetics
Professor Crew on "Science" and Sigma Xi

CONTENTS

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Subscriptions and manuscripts should be sent to the general secretary, Edward Ellery, Union College, Schenectady, N. Y.

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PROFESSOR F. K. RICHTMYER

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SIGMA XI QUARTERLY

EDITORIAL COMMITTEE

FLOYD KARKER RICHTMYER
EDWIN EMERY SLOSSON
HENRY BALDWIN WARD
EDWARD ELLERY

VOL. XVI MARCH, 1928 NO. 1

EDITORIAL COMMENT

The attention of all chapter and alumni members and associates is called to the contents of this number of our official journal. It contains material of great interest to the society and of extraordinary value to the world of science in general. The reports of the secretary and of the treasurer need no comment. They both indicate progress in organization. Our aspiration is to get our twenty thousand and more members and associates so aggregated that the immense organization may become a helpful human influence through its single interest of promoting research in all scientific fields in this country and in the world. Sigma Xi is already represented by its members and associates in fifty-five different foreign countries, as the secretary's report shows.

The society is privileged to present to its members and associates and through them to the large circle of which they are a part the contributions of President Little and Professor Crew. Both are of unusual importance and very high value.

With reference to the enrolment at the Convention the secretary calls attention of the chapters to the following comparison:

Chapters represented at the last three conventions:

Kansas City, 1925, 23 of the 42, or 54.7%
Philadelphia, 1926, 24 of the 45, or 53.3%
Nashville, 1927, 28 of the 46, or 60.8%

Clubs represented at the last three conventions:

Kansas City, 1925, 9 of the 13, or 69.2%
Philadelphia, 1926, 4 of the 15, or 26.6%
Nashville, 1927, 6 of the 15, or 40.0%

The improvement in chapter representation is most gratifying. The national officers anticipate with eagerness the time when the business of our great society will be transacted regularly by at least ninety per cent of the constituent chapters.

* * * * * *

With the close of the calendar year Professor Richtmyer severs his official connection with the society. Sigma Xi has never had a more interested member, nor one who has rendered it a more valuable service. For nearly fifteen years he has been an officer in the organization, first as an elected member of the executive committee, then as president, and for the past two years as an ex-officio member of the executive committee. He has been an important factor in shaping the policies of the society which have resulted in its present position of influence and respect in the scientific world, and in drafting the revised constitution of the society adopted in Boston in 1922. The officers take this means of expressing their appreciation of the services Professor Richtmyer has rendered Sigma Xi and the cause it represents. While his name no longer appears in the list of officers, we know he will watch with unceasing interest the progress of the organization, and generously continue to give his counsel and help. One who has put into a work as much of himself as Professor Richtmyer has put into our society can never completely sever connection with it.

* * * * * *

The officers deeply regret to announce that owing to many demands upon his time and strength, Dr. Vernon Kellogg does not feel able to accept the election to the presidency. During the past five years Dr. Kellogg has been most helpful in directing the affairs of the society, and we had all hoped it might be possible for him to continue on the official board for the ensuing two years. Of course one must respect his reasons for declining the presidency. Sigma Xi gratefully acknowledges his services. We all sincerely trust that his health and vigor will continue for many years to enable him to carry on the great work in which he is engaged.

PROCEEDINGS OF THE TWENTY-EIGHTH CONVENTION OF THE SOCIETY OF THE SIGMA XI

The Twenty-Eighth Convention of the Society of the Sigma Xi was held in the Physics Lecture Room of College Hall, Vanderbilt University, Nashville, Tenn., December 27, 1927.

President Moulton called the business session to order at 2:00 o'clock in the afternoon and appointed the Committee on Credentials as follows:

Professor J. M. Breckenridge	Vanderbilt University, representing the University of Washington
Professor H. D. Hooker	University of Missouri
Professor E. B. Mains	Purdue University.

The committee received the credentials of delegates and reported the following chapters represented at the Convention:

*Cornell	Arthur J. Eames
	Carleton C. Murdock
†Rensselaer	George W. Hunter, 3d
*Union	Edward Ellery
*Kansas	Paul B. Lawson
*Yale	A. F. Kovarik
*Minnesota	Clarence E. Mickel
*Nebraska	J. C. Jensen
	J. E. Weaver
*Ohio	F. C. Blake
*Pennsylvania	Rodney H. True
	Frederick H. Safford
Brown	Not represented
*Iowa	Christian A. Ruckmick
*Stanford	H. F. Blickfeldt
*California	J. L. Collins
Columbia	Not represented
*Chicago	H. C. Cowles
*Michigan	Carl E. Guthe
	H. M. Randall
*Illinois	Elmer Roberts
	H. F. Moore
*Case	D. C. Miller
*Indiana	J. E. Switzer
	W. N. Logan
	M. E. Hufford

*Missouri	H. D. Hooker, Jr.
†Colorado	Ralph H. Brown
*Northwestern	Henry Crew
*Syracuse	L. H. Pennington
†Wisconsin	Edward Bennett
*University of Washington	J. M. Breckenridge (Vanderbilt)
*Worcester	L. G. Wesson (Vanderbilt)
*Purdue	E. B. Mains
†Washington University	H. M. Miller, Jr.
District of Columbia	Not represented
*Texas	E. H. Sellards
†Mayo Foundation	T. B. Magath
*North Carolina	H. R. Totten
North Dakota	Not represented
Ames	Not represented
Rutgers	Not represented
*McGill	F. E. Lloyd
*Kentucky	M. N. States
Idaho	Not represented
†Swarthmore	Arnold Dresden
Oregon	Not represented
*Virginia	B. D. Reynolds
Johns Hopkins	Not represented
California Institute of Technology	Not represented
†New York University	H. W. Stunkard
†University of Cincinnati	H. M. Benedict
	C. N. Moore
	O. T. Wilson
*Michigan State College	E. A. Bessey

* Delegation present at Convention and voting.
† Delegation named to National Secretary prior to Convention, but not registered at Convention.

The following Sigma Xi clubs were represented:

University of West Virginia	L. M. Peairs
Washington State College	F. D. Heald
University of Wyoming	Aven Nelson
Kansas State College	L. E. Call
	G. A. Dean
University of Florida	W. N. Walker
	O. F. Burger
University of Oklahoma	O. J. Ortenburger
	A. O. Weese

Twenty-eight of the forty-six chapters were represented at the Convention and took part in the voting. Eight chapters had named delegates who were not at the Convention. Eleven had not notified the Secretary of the appointment of delegates and were not represented at the Convention.

Six of the fifteen Sigma Xi clubs were represented at the Convention.

Officers were present at the Convention as follows: President F. R. Moulton, Chicago; Secretary Edward Ellery, Union; Executive Committee, Henry B. Ward, Illinois.

The account of the proceedings of the Twenty-Seventh Convention of the Society at Philadelphia, December 28, 1926, published in the March (1927) QUARTERLY, was approved as printed.

President Moulton reported on the activities of the President during 1927, calling attention to the satisfactory condition of the society, and expressing appreciation and enjoyment of the work of his office during his term of two years.

The annual report of the Secretary was read. (It appears in full on page 8.)

In the absence of the Treasurer, the Secretary read the report of the Treasurer. (It appears in full on page 13.)

President Moulton presented petitions as follows:

a. University of Maryland.

Upon the roll-call of the chapters represented, it was voted unanimously to grant a charter to the group of petitioners from the University of Maryland, with the limitation that undergraduates shall be elected as associates only. When installed, the chapter will be designated as the Maryland Chapter.

b. Lehigh University.

Upon the roll-call of the chapters represented, it was voted unanimously to grant a charter to the group of petitioners from Lehigh University, with the limitation that undergraduates shall be elected as associates only. When installed, the chapter will be designated as the Lehigh Chapter.

c. University of Illinois College of Medicine.

Upon the roll-call of the chapters represented, it was voted without dissenting voice to grant a charter to the group of petitioners from the University of Illinois College of Medicine, with the limitation that undergraduates shall be elected as associates only. The question of the name of the new chapter was referred to the Executive Committee with power, with the recommendation that the committee confer with the group of petitioners regarding the name. (Since the Convention the name has been chosen as follows: University of Illinois College of Medicine Chapter.)

d. Kansas State Agricultural College.

Upon the roll-call of the chapters represented, it was voted unanimously to grant a charter to the group of petitioners from the Kansas State Agricultural College with the limitation that undergraduates shall be elected as associates only. When installed, the chapter will be designated as the Kansas State College Chapter.

The Ames Chapter presented, through the Executive Committee, a request that its name be changed to the Iowa State College Chapter. It was voted

> Upon the recommendation of the Executive Committee, in response to a request from the Ames Chapter and following the policy of the society to name chapters in accordance with the name of the institution in which they are located, that the name "Ames Chapter" be changed to the "Iowa State College Chapter."

President Moulton asked if the Convention desired to express itself in an interpretation of the word "science" in Section 2 of Article I of the Constitution which reads: "The object of this society shall be to encourage original investigation in science, pure and applied." The Secretary stated that recent inquiries had been made of the Executive Committee as to whether the society should recognize original work in the field of education, of agricultural economics and of history; and that one chapter had reported a newly-elected member as registered in the department of "Public Speaking." The question brought out considerable discussion, culminating in the suggestion that Professor Henry Crew of Northwestern University be requested to prepare an article for the QUARTERLY on a definition and classification of so-called sciences, and that chapters be asked to make the article the basis of a discussion in a chapter meeting and report results to the national secretary. (The article appears on page 36.)

The Committee on Nominations, announced in the December QUARTERLY and by circular letter from the national secretary to chapter officers, consisted of:

Professor R. Bennett Bean	University of Virginia
Professor M. N. States	University of Kentucky
Dr. T. B. Magath	Mayo Foundation

The Committee made the following nominations:

For President Dr. Vernon Kellogg

For Secretary	Dean Edward Ellery
For Treasurer	Dean George B. Pegram

For Member of Executive Committee for the elective term of five years, Dr. Louis B. Wilson, Mayo Foundation.

For Member of Alumni Committee for the elective term of five years, Mr. Donald H. Sweet (Case), 10 South LaSalle Street, Chicago.

It was voted that the report of the Nominating Committee be adopted and that President Moulton be empowered to cast a ballot for the officers named.

President Moulton announced that the ballot had been cast and declared the officers named duly elected.

Upon motion of the Secretary, the Convention voted that the usual assessment of $1.00 for enrolled members and associates be levied for 1928.

Professor Aven Nelson of the University of Wyoming, and president of the newly organized Colorado-Wyoming Academy of Science, reported on the activities of the Wyoming Sigma Xi Club and the work of the University, expressing the hope that a chapter of Sigma Xi might some time be established there.

Professor Lloyd reported on the activities of the McGill Chapter.

President Moulton voiced the appreciation of the Convention and the officers for the work done by Professor J. M. Breckenridge of Vanderbilt University in arranging for the Convention, for the Annual Dinner, and the Sixth Annual Public Lecture.

The Convention adjourned at 5:10 o'clock to meet at The Hermitage Hotel for the Annual Dinner.

Annual Dinner

About one hundred and twenty members and guests of Sigma Xi met at the Hermitage Hotel at 6:00 P.M. for dinner. Arrangements had been carefully made by Professor Breckenridge, and the hotel management presented a typical southern menu with true southern hospitality. An attractive and ample dining room was placed at the disposal of the Society, and the company was seated and served without crowding or discomfort.

At the close of the dinner, the company adjourned to the War Memorial Building for the Sixth Annual Sigma Xi Lecture, which was delivered by President Clarence Cook Little of the University of Michigan. (The Lecture is given in full on page 16.)

Edward Ellery, *Secretary*

SECRETARY'S REPORT FOR YEAR ENDING DECEMBER 31, 1927

Following is a statistical account of some of the activities of the Secretary's office during the calendar year 1927, with a few suggestions regarding the work:

I—QUARTERLY *Subscribers.*

	Year 1922	Year 1927
Circulation (total)	3300 copies (Sept. issue)	About 7000 copies (6850 subscribers)
Alumni subscribers	30	1200

About 70% of the contributors to the Fellowship Fund are receiving the QUARTERLY at their own request. It is nearly three times as many as requested the QUARTERLY in 1926.

II—Alumni Movement.

Number of circular letters sent out.....About 13,000
Number of circular letters returned (unclaimed).....About 2,500
Number of contributors, 1927.....About 1,400

NOTES

About 30% of letters returned unclaimed were directed to foreign countries.

In the case of many individuals this office has no address whatever. This is due to a variety of causes, one of which is an incomplete record at the time the record cards are sent in. Just recently a set of record cards was received from a chapter secretary which gave only names of individuals.

We are making every endeavor to get and to maintain a correct file of members and associates. Notices of change of address received through the Post Office amount to about 125 per month; notices of change of address received from individuals amount to about 30 per month. In addition to this, we check up addresses sent us through the chapter secretaries, and this amounts to about 425 per month. In other words, we check up on the list of chapter members and associates at least once a year the address of every enrolled member and associate of Sigma Xi.

There are several explanations of this situation. One is that chapter secretaries or treasurers are expected to make reports of enrolled members early in the calendar year. The secretary's office may receive them as late as April or May. By September, the list is considerably changed. This is bound to be the case in all academic circles. A good deal of the work caused by this difference in enrolled membership in the spring and fall would be obviated if secretaries reported enrolment in September or October—in other words, if the fiscal year of the society dated from September to September.

Another cause of the amount of work connected with the subscription list is the fact that the secretary's office maintains one list of subscribers, while the addressograph list is at the publishing house. Corrections are thus necessitated in two places. The Executive Committee is considering the advisability of having the addressograph list in the secretary's office.

III—Geographical File.

The secretary is happy to report that the geographical file is now completed as far as the division into states and countries. The states are now being subdivided, starting with those states from which requests have come for addresses of Sigma Xi alumni in certain sections. The geographical file, at the time of this report, is complete for California and Pennsylvania. Massachusetts will come next in order. As an illustration of the extent to which this filing is being carried out, we know now that in California there are about 1950 members of the society living in 159 different towns. We have sent to the Alumni Club in Los Angeles a list of Sigma Xi members and associates living in southern California, including a special list of those resident within a radius of 60 miles of Los Angeles. We have also prepared special lists for New York City and Chicago sections.

The majority of the membership is located in the United States. About 270 members are in territories and possessions of the United States, and of these the largest number are resident in the Philippine Islands.

The society has over 1000 members residing in foreign countries. The largest number of these are in Canada; the next largest number are in China; and the next largest in South American countries. The following is a list of the countries in which members of Sigma Xi are to be found:

FOREIGN COUNTRIES

Argentina
Australia
Austria
Azores
Belgium
Bolivia
Brazil
British North Borneo
Canada
Chili
China
Columbia
Cuba
Czechoslovakia
Denmark
Dominican Republic
Dutch East Indies
Egypt
England
Equador
Federated Malay States
France
Germany
Haiti
Holland
Honduras
Hungary
India
Ireland
Italy
Jamaica
Japan
Java
Jugo-Slavia
Korea
Manchuria
Mexico
New Zealand
Norway
Palestine
Peru
Poland
Portugal
Rhodesia, Northern
Roumania
Russia
Scotland
Siam
South Africa, Union of
Spain
Sweden
Switzerland
Syria
Turkey
Venezuela

A great many of these alumni are keenly interested in the alumni movement and contributing to the alumni fund. One of our largest contributors lives in Siam (Dr. Nai Kim Bee, Cornell 1914, Government Laboratory at Bangkok); others in Sumatra, Dutch East Indies (Mr. Earl M. Blair, Calif. 1920, U. E. Rubber Plantations at Boenock, Kisaran; Mr. Oliver F. Bishop, Yale 1909, at Asahan, Kisaran, Sumatra).

We have had orders for insignia from Denmark, Sweden, China, Scotland, England, Czechoslovakia, Roumania, etc. Owing to unsettled conditions in China, our correspondence with members in that country has been greatly hampered.

Arranged in order of *number* of resident Sigma Xi members, beginning with the largest, the states may be listed as follows (figures are approximate):

New York	2500
California	1950 to 1970
Illinois	1900
Pennsylvania	1500
Ohio	1200
Michigan	1000
Minnesota	950
Indiana	600
Iowa	500
Connecticut	500
Massachusetts	500
Missouri	500
Wisconsin	500
New Jersey	400
Nebraska	400
District of Columbia	275
Kansas	275
Maryland	250
Washington	250
Rhode Island	250
Texas	250
Colorado	160
Kentucky	150
Virginia	125
Oklahoma	100
etc.	

IV—Insignia.

Since April 15, the insignia of the society for both associates and members have been distributed through the office of the national secretary. In that time, we have handled a total of 497 orders for keys and 191 orders for pins.

In the early months of this work there was a good deal of delay in filling orders, due to the fact that the official jeweler had not had time to accumulate anything like an adequate stock. That difficulty is now removed, and all orders are filled within three or four days of their receipt.

V—Inactive Chapters.

Some of the chapters are apparently not very active. This is indicated by the absence of reports from them, and also by direct statement from officers. One chapter has elected no associates or members for two years; another chapter has held no meeting during the current academic year. In November we sent out to seventeen different chapters requests for record cards not only for the academic

year 1926–27, but in some instances for a few years preceding. In every case this was the third appeal for record cards. We have had orders for society insignia for individuals for whom we had no record in our files.

These facts are stated only in order to show some of the obstacles with which we contend. Chapter officers are urged to keep chapter records up to date and to maintain continuous contact with the central office.

EDWARD ELLERY, *Secretary*

REPORT OF THE TREASURER OF SIGMA XI FOR THE YEAR 1927

The assessments of all chapters except one, the California Institute of Technology, have been paid.

RECEIPTS

Cash on hand, Dec. 31, 1926	$2552.59	
Chapter assessments for 1927	5095.62	
Chapter assessments in arrears	354.50	
Initiation fees	1153.00	
Installation fees	100.00	
Sale of QUARTERLY	2.00	
Sale of Insignia	600.00	
Miscellaneous	13.25	
Interest on Investments	305.00	
Cr. clerical assistance on Alumni Fund (authorized by Executive Committee)	400.00	
		$10,575.96

DISBURSEMENTS

Secretary's office:		
Secretary's assistant	$2091.60	
General	318.32	
Secretary's salary ($240 on 1926)	2040.00	
Treasurer's office	10.00	
Officers' travel expense	317.88	
Engrossing charters	46.85	
QUARTERLY (5 issues)	1391.27	
1 Southern California Edison Bond	1066.69	
1 Pacific Gas and Electric Co. Bond	1048.36	
Miscellaneous	51.60	
Cash on hand, Dec. 31, 1927	2193.39	
		$10,575.96

INVESTMENT ACCOUNT

$1000 American Telephone and Telegraph Co. 5½ per cent bond, carried at	$1037.44
$1000 Consolidated Gas of New York 5½ per cent bond, carried at	1002.90
$1000 American Telephone and Telegraph Co. 5 per cent bond, carried at	991.94
$1000 St. Louis and San Francisco Railway 4 per cent bond, carried at	796.35

INVESTMENT ACCOUNT (*Concluded*)

$1000 Baltimore and Ohio Railroad 5 per cent bond, carried at	955.00	
$1000 Southern California Edison 5½ per cent gold bond, carried at	1045.00	
$1000 Pacific Gas and Electric Co. 5½ per cent gold bond, carried at	1045.00	
		$6873.63

ALUMNI FUND

RECEIPTS

Cash on hand, Dec. 31, 1926	$2000.95	
Receipts for the year from subscriptions	3613.92	
		$5614.87

DISBURSEMENTS

Research:		
Dr. Bruce Fink	$240.00	
Prof. E. S. C. Smith	100.00	
Dr. C. D. La Rue	251.40	
Mr. Floyd Winter	75.00	
Prof. Elbert C. Cole	225.00	
Dr. Roy L. Moodie	400.00	
Mrs. M. M. Brooks	90.00	
Dr. Helen Sorokin	250.00	
Prof. Donald W. Davis	250.00	
Prof. Clifford C. Farr	250.00	
Mr. Oscar W. Richards	350.00	
		$2481.40
Allotment to Secretary's office for work on alumni lists and correspondence	400.00	
Stationery and postage	266.88	
Collection	3.00	
Non-negotiable checks	9.00	
Cash on hand, Dec. 31, 1927	2454.59	
		$5614.87

GEORGE B. PEGRAM, *Treasurer*

Dec. 31, 1927

We have audited the accounts of the treasurer of the Society of Sigma Xi for the year ending December 31, 1927, and certify that the income shown by the books of the treasurer has been duly accounted for, that payments have been properly vouched and that the balance sheet and accounts submitted contain a true statement of the financial condition of the Society. We have also examined

the securities in the hands of the treasurer and find the following bonds: $1000 American Telephone and Telegraph Co., $1000 Consolidated Gas of New York, $1000 American Telephone and Telegraph Co., $1000 St. Louis and San Francisco Railway, $1000 Baltimore and Ohio Railroad, $1000 Southern California Edison, $1000 Pacific Gas and Electric Co.

ARTHUR W. HIXSON
LINCOLN T. WORK
Auditors

SUGGESTED BUDGET FOR 1928

QUARTERLY	$1200
Secretary's office	4200
Travel expenses (executive committee and officers)	600
Engrossing charters	120
	$6120

($400 chargeable to Alumni Fund for clerical assistance.)

Sub-committee on budget,

GEORGE B. PEGRAM, *Chairman*

OPPORTUNITIES FOR RESEARCH IN MAMMALIAN GENETICS

C. C. LITTLE, UNIVERSITY OF MICHIGAN

The Sixth Annual Sigma Xi Address, Nashville, Tenn., Dec. 27, 192

For centuries man has been actively interested in observing, recording and interpreting the phenomena of heredity. Occasionally among the great mass of workers there have been individuals whose achievements have stood out in bold outline differentiating them from their contemporaries, from those who had gone before and from those who were to come. It will be necessary only to mention a few of the most distinguished of these to show the almost unbelievable development of our knowledge of genetics.

At the end of the nineteenth century scientists had accepted Darwin's demonstration of over-production, the existence of variation, natural selection, the elimination of the relatively unfit and the consequent survival of those better fitted to meet required conditions. At the same time many zoölogists had begun to think in terms of soma and of germplasm and had at least gone part way along the road of Weismann's theory of descent. Bateson's "Materials for the Study of Variation" had provided an excellent list of variations and Pearson's school of biometricians, to some extent encouraged by Galton's quantitative theory of inheritance, were busy investigating many problems of genetics in humans and in lower forms.

Then in 1900 came the rediscovery of Mendelism. At the same period De Vries' theory of mutation provided a method for the origin of discontinuous variations. Within five years the reports of the Evolution Committee, and the work of Davenport, Castle and Cuenot showed that Mendelism applied to mammals as well as to many other types. Various color patterns in mice, rats and guinea pigs as well as hair length and form in the latter were among the first cases to be recorded. Within another five years, that is to say by 1910, many new types of genetic material among animals were being used and the star of Drosophila melanogaster had appeared above the horizon.

Three years later the first of Morgan's books on genetics had been

published. "Heredity and Sex" outlined and described the occurrence of sex-linkage and the genetic significance of the sex chromosome along lines earlier hinted at by McClung and by Castle. Definite proof of the correlation between structures in the germ cell and the behavior in inheritance of certain characters had been provided and the hunt for new facts was on. The small size, rapid breeding and economy of Drosophila were supplemented by the establishment of its cytological picture which in comparison with all other animals then being studied was relatively simple and suitable for analysis.

These facts bore fruit and in 1915 Morgan and his associates published "The Mechanism of Mendelian Heredity." It included maps showing the linear order of genes within the chromosome and opened up a whole new vista of definiteness in our ideas of the structure of the germplasm. The Gene moved rapidly into the good social standing and warmed the heart of biologists who had long been no more than politely aware of the terms pangens, ids, idants and biogens.

With the publication of the "Physical Basis of Heredity" four years later, Drosophila showed itself to be a bonanza. Under the superlatively skilful hands and minds of Morgan and his group it had given to biologists four general principles to add to the two fundamental discoveries of Mendel.

Morgan lists the six principles as follows:

1. Segregation
2. Independent Assortment
3. Linkage
4. Linear Order of the Genes
5. Interference
6. Limitation of Linkage Groups

Of these numbers one and two represent the discoveries of Mendel and the other four those of Morgan and his associates.

The physical basis of heredity had thus been placed on a basis of definiteness never before dreamed of, the accuracy of results based on experiments carefully planned and predicted in advance had proven amazing. A really great victory had been won and an epoch-making advance had been recorded.

And then a question, formerly as cold and cynical as the attitude of a present-day fundamentalist, became warm and took on a tone

of far greater intensity of interest. Medical men, lawyers, sociologists, the clergy and educators began to ask "Of what value are these facts to man?"

II

Before that question can be answered let us see why man's attitude toward biology in general and his own in particular has changed and has led him to ask the question as he has. There is no doubt that medicine, law, sociology, theology and education have all of them become much more interested in and considerate of the findings and possibilities of research in human biology than they were one or five or ten years ago. Their changed attitude has undoubtedly been one of the chief causes of the shift in public interest.

Without taking too much time it may be possible briefly to review some of the factors which have contributed to the increased attention now being paid to human biology.

The medical profession taking advantage of greatly improved methods of hygiene and sanitation had developed the preventive phase of its activities very extensively during the past few years. Schools and programs of public health have grown rapidly both in number and in extent. Mass programs dealing with prophylaxis of various types were a common procedure during the late war. They, along with the peace-time programs of public health, have helped to create in the mind of the medical profession a sympathetic attitude toward the subordination of the selfish rights of the individual to the larger needs of the group as a whole.

To strengthen this movement additional impetus came from other directions as well. Among the most interesting of the tendencies which has rapidly been developing to a point of general influence is the emphasis placed upon psychoanalysis and upon the interrelation between glands of internal secretion and various psychoses. The public fancy has been caught and held by the spectacular advances of knowledge in this field. As a result the medical profession more than ever before has shown a willingness to turn its consideration to the general natural biological processes which provide defense against disease and which cause variation in the activity of the glands of internal secretion. These facts, coupled with the realization that psychological abnormalities in many cases trace back to physiological bases which are themselves a definite part of human biology, have helped to increase still further such interest once it is aroused.

In a somewhat similar way sociologists, recovering from their

first skepticism of any "law of inheritance," have noticed the temporary nature of changes induced solely by alteration of environment and the persistence of the variations produced by genetic change. The researches of Goddard on feeble-mindedness have been among the powerful agents in carrying conviction to the doubter. So also have been the numerous studies reported by Newman, Muller and others on identical twins brought up in very different environments.

Whenever the sociologist wearied by the pressure of facts of genetics upon his environmentally inclined mind has attempted recourse to the mossy bank of neo-lamarckism or to the bubbling Watsonian spring of behaviorism he has been prevented from enjoying uninterrupted rest by a nasty and almost continuous noise. This noise is the insistent voice of those all over our country who notice the rapidly rising cost in the care of mental and social defectives. It introduces a particularly blatant note in what might otherwise have become merely a mild academic and scientific discord characterized by *dyspepsia intellectualis*. The raucousness of the new voice is caused by the fact that it originates from the average non-scientific tax-payer from whose purse the hands of the legislature biennially, with as little pain as possible, removes the funds to support those institutions such as state prisons, homes for the feeble-minded, the insane, the paupers, the diseased, the blind, the deaf and the unattached old people. It is a voice which like the sword of Alexander cleaves the Gordian knot of scientific argumentation with a far from gentle insistence on the point that the supply of defectives of various sorts should be controlled and diminished by preventing their reproduction.

Following closely on the heels of this agitation and pouring through the breech thus made, believing that the limitation of production of crippled, diseased, feeble-minded, epileptic or otherwise obviously defective children is both humane and economical the advocates of the spread of contraceptive information for health reasons have aroused a great and growing interest in the betterment of the race and the protection of childhood by the scientific methods of human biological research.

This, in turn, has brought out the fact that certain social or religious groups believe in the production of the greatest possible number of children of all kinds, whether handicapped and sentenced to a life of idiocy and suffering or not.

A healthy deterrent for this point of view is to be found in the community fund method of supporting charities. Because of the impersonal and fair attitude of those obtaining and spending the public funds for charitable purposes under the community idea the groups or organizations engaged in encouraging the production of unwanted and unfortunate children will eventually be recognized and isolated. As soon as this is done the next obvious and unavoidable step will be to insist that those so engaged pay the full expenses of the individuals produced under their guidance who later become public charges of any sort. Not long after that action is taken economic need will do the rest. In view of all these facts and a score of others the consideration of which time does not allow, it is not hard to understand the interested attitude of sociologists.

The legal profession also has been able to utilize advances in genetic knowledge. Mendel's Law has helped in the determination of parenthood and by its definite findings in the case of the inheritance of certain types of feeble-mindedness has greatly aided the advances made in legislation governing sterilization.

The records and family history of criminals also show in many cases such obvious biological foundation for abnormal behavior that supporting evidence for sterilization, under certain conditions, has readily been obtained. The Law as a profession is notably conservative, yet it has among its members a steadily increasing group of outstanding individuals who are interested in obtaining more information on the methods of genetics to serve as the basis for constructive legislation.

The clergy has also become intensely aware of human biology.

Change in social attitudes may mean reform and reform in turn may mean discomfort to the existing stability of a ruling group. It is not surprising therefore to find one group of fundamentalist and conservative members of the clergy holding up as examples of filth and vileness those who are interested in the study of mankind from a biological point of view. On the other hand, the progressive members of the clergy are among the most ardent and alert followers of experimental science. Once these men realize that the acceptance of new truths does not mean loss of caste, they frequently become sufficiently radical to cause some embarassment even to the most advanced of the experimental scientists themselves.

It is a healthy thing, however, to find such an active interest among the clergy and to see that many of them realize that the fate

of international coöperation and of the world peace that would ensue depends very largely upon the characteristics of races and nations. These characteristics are many of them hereditary and so are biological in the most definite sense. Acceptance of this fact has done much to increase reliance in genetic differences and in the research which deals with them.

Educators also are peculiarly aware of the need for more accurate knowledge of the biological nature of the individual.

The great increase in our population has brought with it, quite naturally, an increase in the number of school children. The congestion resulting from this fact has spread from the lower grades of elementary school through all the higher levels to include even graduate or professional work. Selection is increasingly intelligent and strict form has been necessary because higher education is expensive and could not be distributed broadcast to any and every one who merely indicated his wish to receive it.

This has set educators to work in an attempt to develop a wiser and more honest method of rating mental ability than had formerly been in use. Such action was necessary if wise selection was to be practiced. Various mental tests have shown that mental ability is to a considerable degree definite, measurable and analyzable. They have also shown beyond any doubt that differences both in type of mental ability and in extent of general mental development are present in very young children. As a result, pre-school units have been greatly developed. Child-study even with infants has become increasingly emphasized and will undoubtedly grow to even far more extensive proportions. No more impressive demonstration of the genetic and biological basis for individual differences in man could be obtained than are facts derived from such study.

The possibility that we may some day be able to predict achievement in the early years and so prevent waste of promising human material has come to the front with greater vigor and more hope than ever. As a result the mind of the educator is open today as never before to a sympathetic consideration of and interest in genetic research.

By very different but by converging roads the alert progressive phases of medicine, sociology, law, theology and education have thus met to combine in asking the laboratory geneticist the question already referred to, namely, "Of what value to humanity are all your findings?"

III

It is very evident even from the very imperfect statement of the situation just made that there is a wide and somewhat awesome gap between the details of the structure of the germ cell in Drosophila and the wise direction of a program of improvement in human biology.

Jennings, in his recent address as retiring president of the American Society of Zoölogists, expressed most intelligently, and to me most convincingly, the dangers and difficulties of applying in detail the conclusions drawn from results obtained in the study of the genetics of one form to the untried performances of another unrelated type of organism.

I shall not attempt here a comparison between the obviously widely divergent fields of plant and animal genetics but merely indicate a few of the differences which appear to me to be critical and insurmountable barriers in the road of interpreting the detailed genetic problems of man on the basis of work, no matter how skilful, done with Drosophila or other insects.

The object in doing this is in no way a desire to discredit the splendid work done in the field of insect genetics. It is merely an attempt to show that the gap between the laboratory phase of experimental genetics and the interest in human biology will not be abridged by research in forms as widely separated from man as are the insects.

Insects are remarkably definite and fixed in a biological sense. From the very egg—itself more or less definitely organized into zones or regions—it shows a tendency to specialize its structures for detailed and well-defined objectives. The segmental arrangement of antennæ, body and legs is further evidence of detailed morphological differentiation. The compound eye is a sort of declaration of morphological policy which is characteristic of insects.

The normal physiological responses of insects are also very detailed and definite. The independence of secondary sex characters from the secretions of the gonad is a typical example of the independence of organs and tissues which exists in insects. The phenomenon of a complete metamorphosis is also an indication of the discontinuity and highly evolved organization of the developmental process in insects.

The vast number of instinctive responses in insects shows that their psychology shares to a high degree the particulate and mosaic type

of constitution that applies to their physiology and morphology as well.

It seems quite natural then to find that in most of those insects already studied the germ cells are highly definite and regularly organized. One would expect nothing else if the germ cell is to be considered a characteristic part of the individual and a reasonable precursor to the organisms arising from it.

Man lacks much of this definiteness. Beginning with an egg that appears to be more completely interdependent in its various parts than is that of insects he develops during his embryonic life in a carefully controlled environment. Constant internal temperature, moisture and food conditions allow the free development of a balanced and elastic type of organism.

Interchangeability of body fluids, dependence of form, rate and extent of growth and maturity upon internal secretions and relative elasticity and indefiniteness of mental processes—all are directly in contradistinction to the conditions found in insects.

It would not be at all surprising if in mammals the internal organization of the germ cell itself including the interrelationships between cytoplasm and chromosomes and between chromosomes themselves were much less definite and predictable than are those of insects. In fact a recent paper by Miss Swezy in *Science* showing that the ordinary white rat may have either 42 or 62 chromosomes without marked morphological change seems to prove that in one case, at least, such is the case.

It is true that there are chromosomes in insects and in mammals and that there is likewise evidence for Mendelian inheritance in both forms. To draw close homology or even analogy, however, between the detailed genetics of man and of insects would be exceeding our present knowledge. There is a real gap between the two forms.

There is, however, already in position the foundation of the main support of the bridge over the gap referred to. It has not yet been built high enough for a level and comfortable transition but it has definite possibilities and as I see it must be constructed before we can expect much real progress in human biology. The structure to which I refer is the steadily growing mass of information being obtained in the field of research in the genetics of the laboratory mammals.

IV

To collect data which will help to bridge the gap we must observe certain general rules of experimental procedure.

First the problems to be investigated must be of interest to man. One cannot expect by mammalian genetics to extend the influence of, or deepen interest in, human biology unless the problems investigated have some connection with those of the larger human field. Fortunately the great majority of problems which are capable of study in the laboratory mammals are of just that sort—as I shall try presently to show.

It is also necessary that the problems connect with known genetic phenomena; that they trace back to some sort of relationship with research in genetics of lower animals or plants. Unless this is the case the benefits of the general principles and fundamental values of the relation between biology and its more exact sister sciences, physics and chemistry, are apt to be lost sight of. The bridge, in other words, if it is to function properly, must have well developed approaches from both sides.

Besides being of interest and value to humans and being based on sound genetic theory the problems must be capable of investigation in economic and suitable material. The last requirement is, of course, purely practical, but for the purposes of successful experimental procedure, it is essential. Among mammalian material the types which are favored for experimental work are at present practically entirely confined to two carnivors and four types of rodents.

Cats offer interesting color differences, certain structural variation such as short tail and polydactylism, variation in length of hair, and the best case of sex linkage known in laboratory mammals. For breeding purposes in great numbers, however, they are a bit too non-social and are subject to epidemics.

Dogs have a great wealth of color, varieties, and of morphological, physiological and psychological differences. In these respects and in their small number of chromosomes they are unique among laboratory mammals. They are slow-breeding and expensive to raise but they will undoubtedly eventually be used on a large scale.

Among rodents, rabbits are the largest and slowest breeding of those used. They have few genetic morphological variations but a good list of color differences and between some varieties marked difference in size. They have also a good reputation as material for experimental medicine and are valuable for serological experiments.

Guinea pigs (in spite of excellent press agent work by Ellis Parker Butler) are nct very rapid breeders. Their morphological variations are almost as scarce as rabbits and their average number of young

per litter (between 2 and 3) is very small. Their number of color varieties and their chromosome conditions are not radically different from those of rabbits.

Two types of rats provide distinctly better material than either of the foregoing. With a fair number of color varieties they combine a high degree of fertility and relatively rapid rate of maturity. Their size makes them economical of space and convenient for most forms of operative technique. Mice of two genera (*Mus* and *Peromyscus*) appear, however, to be even better material than is any of the other types. Only slightly inferior to rats in respect to litter size they have many more color varieties, more morphological types, far greater size differences and a number of distinctive physiological characters. Three available species of the genus Mus afford an excellent chance for the study of hybridization and its accompanying phenomena. The mechanical advantages of mice are also great. They are only about one-fifth as large as rats and therefore are much more economical of food and space. They mature much more rapidly and provide embryos of convenient size for histological study and sectioning *in toto*. In my opinion they offer the best material for experimental genetic work with mammals.

With this brief review of the qualities of different types of available material let us consider the fields of research particularly of interest to mammal genetists.

V

There are at least five great divisions of genetic problems which are capable of successful investigation in laboratory mammals and which fulfil all conditions outlined above being of interest to man, and in close contact with other fields of experimental genetics. These problems include the genetic bases for size and growth, fertility and sterility, susceptibility or resistance to disease, lethal action of genes during development and psychological differences.

Although there will be undoubtedly inter-relation between the five fields they will each be able to provide ample chance for fundamental and continuous research. Let us review each of them briefly.

A. Size and Growth.—Investigations by Sollas reported soon after the rediscovery of Mendelism showed that dwarfism in guinea pigs was inherited as a recessive, in some way related to sex. Castle showed that ear length in rabbits was inherited but by no simple method; MacDowell carried the problem farther in a de-

tailed study of body weight and skeletal measurements in rabbits. Weight and Castle both contributed to the discussion of the nature of the genetic factors involved. Detlefsen in recording a cross producing hybrids between the common guinea pig and a related wild species showed the relation of the growth rates of the three types. The two greatest opportunities for the study of size inheritance in mammals are, however, as yet practically or entirely undeveloped. Dogs, in which artificial insemination is possible and where body weight is fifty times or more as great in such a variety as St. Bernards as it is in Chuahuas are splendidly fitted for use in investigations of size inheritance.

A cross between *Mus musculus* and *Mus wagneri* would also provide excellent material. The size difference is striking. It would be easy to back-cross the hybrids with either parent and to raise and save the skulls and long bones of thousands of animals in each generation. There are enough color genes already described in *Mus musculus* to run a good chance of finding any existing linkage between genes for color and those for size.

In addition to factors involving general size and growth there have been several cases of localized growth phenomena which have been investigated. The inheritance of short tail in mice, dogs and cats has been shown in each case to be a Mendelian dominant over normal tail length. Polydactylism in guinea pigs and cats is dominant, while when associated with other digital abnormalities in mice it is recessive and influenced by modifying genes; an abnormal jaw and buccal cavity in mice is also recessive and lethal. Uncontrolled or abnormal growth of certain teeth in rats seems to occur in families although its method of inheritance is not as yet clear.

The great morphological variations in dogs have provided and will continue to offer a splendid field for study. The shortened and crooked legs of the dachshund and the curled tail of the chow have proven to be Mendelian dominants. Recently, recognizing the great value of dogs as genetic material, Stockard has started a series of experiments to determine the relation of morphology to glands of internal secretion. The results will be awaited with great interest.

The work of Davenport on the inheritance of stature and that of other investigators on different forms of dwarfism in man show that such comparative studies would be valuable. The genetic importance of different local variations in morphology are also well known in man. Polydactylism and brachydactylism are inherited

and the latter may possibly be lethal if present in a homozygous condition according to the work of Mohr—there is ample evidence that the study of these problems in laboratory mammals would have a direct interest for human biology.

B. Fertility and Sterility.—Differential fecundity and fertility in man lie at the foundation of the relative rate of increase of different nationalities and social groups. Laboratory mammals are well adapted for study in this general field.

The opportunity to make specific crosses is excellent. Detlefsen found a most interesting case of partial sterility related to sex in hybrids of *Cavia rufescens* and *C. porcellus*. Several investigators have found diminished fertility among F^2 and subsequent hybrid generations in a cross between Japanese waltzing mice (supposed to be derived from *M. wagneri*) and common mice (*M. musculus*). Crosses between *M. musculus* and *M. wagneri* and *M. musculus* and *M. faroensis* have recently been made and will be available for further study.

A more accurate measure than ever before of fertility of female mice is provided by the technique developed by MacDowell which enables us to count the actual number of eggs liberated at any ovulation. Among dogs the average litter size of such breeds as airedales is very high, probably in the neighborhood of nine, while the greatest number in such breeds as Chuahuas is two or three, thus providing a splendid chance to determine whether the difference is inherited. Injections of extract of the pituitary has been shown by P. E. Smith to result, in mice, in greatly increased numbers of eggs at any one ovulation. As many as 29 implanted embryos have been counted in a single pregnancy by Smith although the largest litter recorded at birth among the tens of thousands of cases in our laboratory is fourteen. By this technique we can evidently introduce an interesting experimental factor. In addition to this the effects of temporary sterilization induced by x-rays or other means is open to study. It is a well recognized and easily obtained phenomenon.

Although these things are apparently disconnected, they all have a direct bearing on human genetics. So also have the numerous investigations made on the effects of reproductive overwork, the relation of nutrition to fertility and the effects of these various things on the course of the œstrus cycle.

The possibility of controlling the sex ratio by altering experi-

mentally the body fluids of the female reproductive tract, the modification of the sex ratio by other agents such as x-rays, hybridization, or artificial insemination with sperm of different ages are also matters for study in laboratory mammal material which is rich in its opportunities in these and in allied fields.

C. Susceptibility or Resistance to Disease.—There are two general types of pathological conditions which will be open to investigation in laboratory mammals. The first of these deals with infectious diseases.

Wright has shown that inbred strains of guinea pigs may differ from one another in respect to their susceptibility to tuberculosis. Hagedorn has published evidence which he believes demonstrates hereditary differences in susceptibility to an intestinal infection in hybrids of waltzing and tame mice. Tyzzer has described a microorganism which lives within the cells of the liver and causes death to Japanese waltzing mice but not to ordinary non-waltzing varieties. There is undoubtedly a great field for research in this general line of work. Slye has frequently shown clearly that there are particular strains and families of mice in which death due to infection of various types is much more common than in others—thus suggesting hereditary differences in this respect.

A second type of pathological condition resulting in structural or functional defects is known to be genetic in several cases. Cole has described the inheritance of paralysis agitans in guinea pigs as a Mendelian recessive. Stockard and Papanicolau found a number of cases of disequilibration and nervous tremor in successive generations of guinea pigs following treatment of the ancestral generation with alcohol fumes. Przibram found hereditary deafness common in blue-eyed white cats and Yerkes found that after the sixteenth day all waltzing mice are deaf. In this case waltzing and its accompanying deafness are inherited together as different manifestations of the same Mendelian recessive. Keeler has recently described a rodless condition in the retina of certain albino mice. Here also a simple recessive character is involved. Jones has obtained in experimental animals a strain of rats in which reduction of one or both eyes is inherited but not in a simple Mendelian fashion. In the descendants of x-rayed mice Bagg and the writer have described inherited eye and foot abnormalities and Bagg has recorded absence or reduction of one or both kidneys which is also inherited.

In man there is a whole series of structural or functional diseases

which are inherited. Hemophilia, nystagmus, hypospadias, Huntington's chorea, diabetes insipidus, xeroderma pigmentosa, and alkaptonuria are examples chosen at random to show a wide range of characters which may be affected.

In addition to the conditions already mentioned the hereditary tendency to form mammary and other forms of cancer has been investigated. A number of investigators, Tyzzer, Strong, Haaland, Loeb and Lathrop, Slye, Lynch, W. S. Murray and the writer have published a considerable body of papers in the general field of genetics of cancer. At present it seems as though in mice, mammary cancer behaves as a Mendelian dominant the manifestation of which is limited normally to the female sex. Slye's work shows also that different families or strains may be developed in which the particular localized types of tumors are relatively constant for any particular group. Many of the types other than mammary cancer are in no way sex-limited. The evidence for the exact method of inheritance of the tendency to cancer in man is naturally not so direct or so easy to accumulate. There is no reason at present, however, to lead one to believe that the conditions in man are widely different from those described in mice. It can easily be seen that the genetics of comparative pathology will be one of the most important divisions of the general field of mammalian genetics as future developments are recorded.

D. Lethal Action of the Gene during Development.—Lethal action of a Mendelian gene in animals was first discovered in mice. Embryological research by Kirkham, Ibsen and others established the correctness of an hypothesis based on experimental genetics on the inheritance of dominant yellow coat color in mice. The hypothesis advanced by the writer and Castle (1910) was that homozygous yellow mice started but did not complete their embryonic development. Such being the case it follows that an excellent chance for investigating the nature of lethal factors is offered.

In mice also a dominant type of spotting producing, when in combination with the ordinary piebald spotting, a variety known as black-eyed white also acts as a lethal independent of yellow coat color. Detlefsen and others have recorded the appearance at birth, and the survival for a few days thereafter of a pale whitish anemic type of young. This they have described as being the homozygous black-eyed white. It may be that such is the case. The writer, however, has found what appear to be similar young in the

cross of black-eyed white by piebald from the same stock. Since all black-eyed whites in that case are heterozygous it would not be possible for homozygosity of the factor for dominant spotting to have caused the lethal action. Wriet has described a dominant spotting in merle "dunkerhunds" which causes death if present in a homozygous form. The short-tailed variation in mice is also described by Nageli as a clear case of dominant lethal. Mohr as it has been stated above has published some evidence that brachyphalangy in man acts like a lethal. The writer and Gibbons have tried to show by a statistical analysis of human pedigrees of hemophilia and color blindness that there were certain physiological factors at present unidentified but lethal when present in any situation unbalanced by a normal gene. In the cases recorded they chanced to be sex-linked and therefore distorted the sex ratio so clearly as to be recordable statistically.

The relation of lethal factors to the occurrence of still births in man is a matter for attention and research. It should prove to be a fruitful and interesting field of coöperative endeavor between mammal geneticists and the medical profession. Data obtained from the Sloane Maternity Hospital in New York showed that there are fewer still births when the parents are from different nationalities than when they are of the same. Whether this means that the embryo which in a relatively inbred race was not able to survive and that the embryo derived from a cross between nations showed heterosis or hybrid vigor and so survived is not known but should be further investigated.

Lethal genes are interesting not merely because they may account for considerable lowered fecundity through early mortality but also because in studying the process of disintegration of the embryos killed by lethals we may be able to get a better idea of the nature of growth, morphogenesis and of the development of the gene's activity at different stages in ontogeny.

E. Psychological Factors.—The evidence of inheritance of general mental ability in man is strong enough to be an impetus to further research. From Galton's study of men of genius to Wood's more recent investigation of the same general topic and Banker's research on families of Harvard alumni a mass of facts has been piling up to show the hereditary basis for ability.

Special abilities also give evidence of a genetic foundation. The work of Stanton, Seashore and others in the analysis of musical

ability and in tracing the inheritance of its various component parts sets a standard for this type of investigation.

The field of genetics of psychological characters in laboratory mammals is almost a new one. The relation of habit formation, associative response, learning, memory and other psychological phenomena to various genetic phenomena such as inbreeding, hybridization, overcrowding, isolation, malnutrition and to the activity of the glands of internal secretion will offer important fields of research for decades to come. Bagg and Vicari have already independently shown differences in rate of learning between inbred strains of mice and the latter has demonstrated an effect of heterozygosis following hybridization of two such strains. MacDougal believes that he has evidence of the inheritance of an acquired habit or ability in rats. Pavlow has described experiments with mice in which he attempts to prove that the effects of learning are inherited. His work has been repeated with negative results by other investigators and might well have followed rather than preceded a careful and extensive study of the normal racial and individual variation in the process of learning in mice.

Dogs will also provide admirable material for the study of the genetics of psychological phenomena. Habits such as "pointing," "setting," "springing," "giving-tongue," "going to earth" and a number of other natural responses can be studied and compared with the great number of types of habits following training, that will bring out marked individual differences in ability.

Both dogs and mice have enough physiological and morphological variations to provide an excellent opportunity for the investigation of linkage between psychological and physical characteristics. Possibly from such research will come more definite and extensive knowledge of the nature of many of the fundamental mental processes.

The importance of such investigation to education is very evident and when generally recognized is certain to mean increased experimentation and coöperative research between schools of education and departments of mammalian genetics.

The necessarily imperfect and hurried survey of five broad fields of possible investigation can now be considered from the point of view of four great general unanswered problems. These are the permanency of genes, the relation of soma to germ plasm, the nature of the gene as shown by its activity during ontogeny and the possibility of producing genetic change by gradual action of various substances.

A. The Permanency of Genes.—The recent work of Muller has shown that in Drosophila the rate of genetic change by mutation is very rapid. So high is it, in fact, that the usefulness, in that material, of the pure line hypothesis of Johannsen, and the genetic fixity and relative unity of inbred lines seem very much in doubt. It may prove a great handicap to future research to have a form so subject to mutation that its stability, when desired for testing purposes, is not reliable.

It will at all events be desirable to investigate, in addition, such forms as mammals, in which the rate of mutation at various ages and under different types of physiological or other environment can be observed. We know from the work of Strong and the writer that in mice the normal and characteristic development of the individual proceeds from an initial phase of relative undifferentiation to the peak of physiological individuality at the young adult stage of the individual. As the animal approaches senility there appears to be evidence that its degree of individual differentiation again decreases and that this condition continues until the death of the animal. Senility thus at least superficially resembles a physiological "second childhood."

If now, as the work of P. E. Smith shows, it is possible to bring on the process of ovulation at an earlier than normal age by injections of anterior lobe of the pituitary, we shall be able to increase the scope of our field of experimentation. It may also be possible to prolong ovulation in mice which in other respects are approaching senility by the same method or by some other type of rejuvenation process. This will enable us to study rate of mutation under varied internal environments. Quite as good a chance of studying the permanency of genes is afforded in males of different ages.

The effects of changes in the gene would, of course, be measurable in respect to rate of maturity, degree of fertility, length of life, rate of growth, susceptibility to disease, and a number of other processes which are very difficult to study experimentally in animals with too short a life span. The additional fact that transplantation of various normal and neoplastic tissues in mice have given us a means of analyzing the genetic nature of many physiological processes is a further indication that variations by mutations other than those of form or structure will be more easy to detect in these animals than they would in forms where transplantation is not so easy.

B. Relation of Soma to Germplasm.—The classic experiment of

Castle and Phillips (1909) in which black young were obtained from eggs derived from ovaries of a black female guinea pig transplanted to the body of a white female gives clear indication of the opportunity which exists in mammals for research on the relation of soma to germplasm.

While the particular characters used by Castle and Phillips as tests of whether an influence of the foster mother could be detected were not ideal, there are many others which can give us information of a more accurate nature. The use of a color character of the type involved in the difference between colored and albino animals is not as well calculated to demonstrate minor degrees of modification as would be a test involving such differences as those of spotted animals as contrasted with solid colored ones, or of the more subtle physiological characters, such as susceptibility to transplanted tumor or inherited differences in size. In these cases, as well as in psychological traits, it is easier to detect the minute quantitative variations or modifications which are not so readily detected in the case of color characters of the sorts used by the investigators referred to.

To provide an additional field of research, the possibility of regeneration of ovarian tissue in mice, recently described by Davenport, suggests that a new line of approach to both changes in mutation rate and in the relationship of germplasm to soma may be developed.

The techniques of MacDowell and of Nicholas show that we may, with care, expect to develop methods by which we can obtain more accurate first-hand knowledge of what is going on during the stages of ovulation, fertilization and embryonic development. This should aid greatly in solving certain of the problems of relationship between maternal and embryonic tissue, and so contribute directly to the general question of the inter-relationship of soma and germplasm.

C. The Production of Genetic Change by Gradual Treatment.--Mammals are peculiarly fitted for experiments in this general field. Besides providing us with a wealth of different types of characters to be studied, time is afforded during the various stages of the development of the individual so that we may analyze with considerable accuracy both experimental treatment and its effect.

Stockard and Papanicolaou's work in guinea pigs with alcohol fumes, and Guyer and Smith's experiments with rabbit lens antibodies are two well recognized cases in point. In addition, Bagg and the

writer have reported morphological genetic variations in the descendants of x-rayed mice, and J. M. Murray has published a preliminary note on some of the direct effects of irradiation. Jones has cooled and dried the Fallopian tubes and uterus of rats of the selected inbred Wistar Line "A" strain in the early stages of pregnancy. Certain of the young derived from implantation following this treatment had defective eyes. The defect appears to have been inherited. Numerous investigators have shown direct effects on growth, size, and fertility, by dietary changes; and Johnson (unpublished work) has found changes in the same direction by repeated exposure of young mice to ultra-violet light. These investigations suggest that repeated treatment by any or all of these means can be made a method of testing whether germinal change can be induced by gradual modification of environment. Mice which commonly give four generations per year and yet have an individual life span of two years or over are ideal for work of this type.

The possibility of the transmission of immunity slowly acquired is also worth careful study, and is capable of much more interesting analysis than has yet been given it.

By using these and other methods the old but always interesting question of "use and disuse," if taken in its broadest meaning, will, in laboratory mammals of known genetic types, be capable of new and more important investigation under experimentally changed environments.

D. The Behavior of the Gene during Ontogeny.—After the gene has been located and the chromosome mapped with great accuracy, we shall still need to know all that we can concerning the gene as an activator, deterrent, inhibitor, or other influence on structure and function during ontogeny.

We cannot avoid the fact that until it is translated into terms of activity the gene will remain an inert locus in the gamete and will not be analyzable or even describable in any significant terms. It is not at all necessary to subscribe to the old fixed correspondence between gene and character which lay at the basis of much misunderstanding and discussion following the earlier work of Cuenot and of Castle. One may cheerfully admit that many genes influence the appearance of every character and take part in its development, or that any gene may influence many or all characters of an individual organism. One may also willingly agree that the gene is the fundamental basic and localizable unit in genetics. In spite of all these

things, however, we are also forced to admit that a gene remains at present without any distinguishing characteristic unless it is measured in terms of developmental processes which we have been accustomed to call "characters."

For the investigation of such processes laboratory mammals are remarkably, if not uniquely, adapted. With internal moisture and temperature controls, with a relatively continuous type of development, with a life span and size scale fitted for the detection of minute quantitative variation in rate, extent, and form of development, they are as well fitted for the advanced study of the activity of the genes as are any organisms at our disposal.

Those interested in problems of theoretical genetics, those engaged in medicine, sociology, law, theology, or education, those interested in human biology, racial modification, or even individual development from any angle, may all combine in awaiting advance in experimental studies of the types mentioned.

The rapid multiplication of mankind has forced the attention of man upon himself and his neighbors. His attention will remain there, his study be focused there, his major problems will arise there, and there his chief success and failure will be experienced from the present time until a cataclysm reduces his numbers by hundreds of millions, or his control of his own physical and psychological progress, based on sound research, is determined and insured by inspired scientific leadership.

WHAT GROUP OF SCIENCES DOES SIGMA XI REPRESENT?

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At the recent Nashville Meeting of our Society an ancient problem, one at least as old as Aristotle, presented itself. The question arose as to whether men working in a special field of science, which may be called X, are entitled to membership in our group. The discussion was conducted on a high plane, without the slightest indication of narrowness, exclusiveness, or snobbishness; and although the debate did not reach the final stage of resolutions adopted, it left all of us with the general impression that whether or not the votaries of subject X should be admitted to our company depends entirely upon our definition of that science of which we are "eager investigators."

The President of our Society was in the chair and sensed the humor of the situation—a group of scientists discussing the meaning of their own profession. He brought the remarks to a close by asking the writer to explain in the QUARTERLY, and in words of one syllable, the content of the word *science* as employed by The International Congress of Arts and Science held in St. Louis in 1904. What follows is a response to his request.

The committee of three charged with the organization and guidance of the St. Louis Congress was composed of its president, Professor Simon Newcomb of Washington, D. C., and its two vice-presidents, Professor Hugo Münsterberg of Harvard and Professor Albion W. Small of the University of Chicago. The comprehensive and eminently successful plan which these gentlemen devised, initiated, and executed is based entirely upon their definition of *science*, or, if you prefer, upon their analysis of *knowledge*, for, in the title, Congress of Arts and Science, the word science is used, in its wide and etymological sense, as the equivalent of the entire body of orderly knowledge.

The difficulty of defining science lies, as every one knows, in the fact that human knowledge is so dovetailed together that no sharp lines have ever been found separating one field from another, except, of course, in college catalogues. However, there is no uncertainty about the difference between daylight and darkness, whatever the difficulty of saying just where one begins and the other leaves off.

So there is no doubt in the minds of the St. Louis committee that the first great rift in human knowledge is that separating the sciences which deal with phenomena from those which deal with human purposes. Their view is established at the very start upon the assumption that the sciences of phenomena—the Greek *appearances*—are not the whole story. The sciences of Law, Literature, Politics and Economics have to do mainly with the execution of certain purposes; they are in fact the expression of various purposes; while the sciences of Chemistry, Biology and Psychology are concerned mainly with phenomena, that is, with the various aspects under which Nature presents herself to the observing mind.

Each of these two hemispheres of science is again naturally divisible into two parts. Those sciences of purpose which deal with individual will-acts are quite distinct from the sciences which represent, so to speak, the purposes of the entire human race. In contrast with the personal decision of Abraham Lincoln to sign the Emancipation Proclamation, stands the decision of all mankind that the square on the hypotenuse is equal to the sum of the squares on the other two sides of a Euclidian triangle. The well-known individual purpose which Charles Dickens had in writing *Oliver Twist* is essentially different from the determination of all humanity to believe in the Golden Rule, or to unite in admiring the beauty of the Parthenon.

These general judgments, which we, in harmony with all other sane men, have approved and which represent for us truth and beauty and morality, are grouped in Division A and are called the *Normative Sciences*. They include Mathematics, Logic, Aesthetics, Ethics, etc. The normative sciences may therefore be defined as those which deal with over-individual purposes; they are, indeed, the sciences which furnish us the norms by which we believe ourselves to be bound in the process of correct thinking.

The second division of the sciences of purpose includes those will-acts for which a single individual is responsible. Here belong not only such clearly individual will-acts as, say, the determination of Mr. Wilson to attend the Peace Congress at Versailles, but also such group action as the approval of the XVIII Amendment, which approval was nothing more than the individual will-acts of a majority of the members of the various state legislatures throughout the Union. Since history is entirely composed of just individual will-acts this Division B is called the *Historical Sciences;* they are con-

cerned only with the past and its interpretation, not at all with the discovery of natural laws.

Passing now to the sciences which study phenomena, one finds here also a perfectly natural two-fold division. There are certain phenomena which are independent of any individual, phenomena which are universally the same all the world over, and apparently all the cosmos over. The hatching of a chick from the egg of a hen, the rise of water in a capillary tube, the crystallization of copper sulphate from its solution in water, the disintegration of radium; these are all phenomena which are independent of latitude or longitude; given the same circumstances, the same "appearances" always follow, whoever the observer. The sciences which investigate this group of phenomena are classed as Division C, and are called the *Physical Sciences*. Here one naturally finds physics, chemistry, biology, etc.

On the other hand, there are many phenomena which are peculiar to individuals. The content of your consciousness is not only different from mine but is different also from that of every other individual whom you meet. The study of these individual phenomena gives us the *Mental Sciences*, which form Division D, the last of the four great fields in which all the pure sciences have been allocated.

The pure sciences, however, do not tell the whole story. The St. Louis plan includes three more divisions under which are grouped the various *Practical Sciences*. Here these practical sciences are not treated as mere applications of theoretical sciences. They are put on a higher plane; they are recognized as "self-dependent sciences whose "material is differentiated from that of the theoretical sciences by the "different point of view and purpose" (Proceedings of the Congress, Vol. 1, p. 120). This definition is clearly based upon the belief that there is really no more justification for calling engineering applied physics than for calling physics depracticalized engineering Human purpose lies at the bottom of the definition and leads at once to the following three-fold classification.

Those sciences whose aim refers to "the world of things" are described by the adjective *Utilitarian* and form Division E. Here one finds medicine, the various forms of engineering and economics. When our chief consideration refers not to *things* but to *subjects* other than ourselves, we have a Division F, which may be properly denominated the *Sciences of Social Regulation*, including Politics, Law, Sociology, etc.

When, finally, the aim is the development of the subject himself, the culture of the individual, we are already dealing with education, art and religion, all of which are placed in Division G and are called the *Sciences of Social Culture.*

Such is a hasty outline of the four fundamental divisions of pure science and the three great divisions of practical science. No one knew better than this committee of three eminent scholars that these lines of separation were not sharp. They were all men of affairs. That the scheme had a real and pragmatic value is shown by the thoroughly harmonious manner in which the Congress with its seven divisions and its twenty-four different departments performed its assigned functions during the entire week allotted to it. The full value of the plan is realized, however, only by turning the pages of the eight large octavo volumes (Houghton Mifflin & Co., 1906) which contain the proceedings of the Congress and which, as a concise, correlated and readable cross-section of human knowledge at the end of the 19th Century, is perhaps without a peer.

There remains still unanswered the question raised at the Nashville Meeting. What science does ΣΞ represent? This query might have been answered on historical grounds if, back in 1886, any such list of charter sciences had been made *and* if members were agreed not to change the list. Fortunately neither of these conditions hold; and we are free at each general session of the Society to define, redefine, and modify our practice. The problem is here proposed not for the purpose of advocating any one answer; but simply to present a common basis of consideration—the St. Louis Analysis of the Sciences—either for chapter discussion or for the formation of individual judgment.

However it is perhaps only fair to any one who has read thus far, that the writer should record his own judgment as to the best solution of the problem.

Briefly, then, it is as follows: ΣΞ ought to include

(i) that department of the *Normative Sciences* which consists of Mathematics, since its norms and methods are among the foundation stones of the other sciences,

(ii) the *Physical Sciences* with its six departments, namely, Physics, Chemistry, Astronomy, Sciences of the Earth, Biology and Anthropology,

(iii) of the *Utilitarian Sciences,* the first two departments, namely,

Medicine and the various branches of Engineering, all of which are included under the department of Technology.

From this point of view, the ΣΞ would leave the *Historical* and *Mental Sciences*, as well as those of *Social Culture* and *Social Regulation*, to be cultivated by the society which takes "Philosophy to be the guide of life" (ΦΒΚ) and by other similar organizations; and would bend its energies to the encouragement of the young and eager and gifted minds who find their greatest pleasure in advancing

(i) Mathematics
(ii) Physics
(iii) Chemistry
(iv) Astronomy
(v) Science of the Earth
(vi) Biology
(vii) Anthropology
(viii) Medicine in its various branches
(ix) Engineering in its different branches

The foregoing answer makes no pretense to represent any view but my own. The judgment which it expresses is that ΣΞ stands mainly for the *Physical Sciences* (used in the wide Greek sense of the word *physical* to include the sciences which deal with life) and for their three allies, *Mathematics*, *Medicine* and *Engineering*.

EVANSTON, ILLINOIS
January 19, 1928

LOUIS B. WILSON

DONALD HOWARD SWEET

Photograph by Moffett

UNIV. OF MICH.

THE NEW SIGMA XI OFFICERS

DR. LOUIS BLANCHARD WILSON was born in Pittsburgh, Pennsylvania, December 22, 1866. He attended the Pennsylvania State Normal School, 1886, and received the degree of M.D. from the University of Minnesota, 1896. He taught in the high school in St. Paul, 1888–1896; was senior demonstrator in pathology and bacteriology in the University of Minnesota, 1897–1904; was first assistant bacteriologist, Minnesota State Board of Health, 1896–1904, and has been in charge of the laboratories in the Mayo Clinic from 1905 to the present. He has been professor of pathology and director of the Mayo Foundation since 1915. He has been interested in diphtheria and hemorrhagic septicæmia groups; variations in morphology and virulence of Bacillus diphtheriae; etiology of the so-called spotted fever of the Rocky Mountains; pathology of goiter; relation of gastric ulcer to gastric cancer; tumors of the kidney; pathology of spleen and prostate; tumors of parotid; ballistics in relation to gunshot wounds.

Dr. Wilson has given a great deal of attention to graduate medical education.

LOUIS B. WILSON

DONALD HOWARD SWEET holds the degree of Bachelor of Science in Mechanical Engineering from the Case School of Applied Science, of Bachelor of Arts from Adelbert College of Western Reserve University, and of Bachelor of Laws from Chicago Kent College of Law. He was elected to Sigma Xi in the Case Chapter.

Mr. Sweet has filled the following positions:

Laboratory Assistant to Dr. Dayton Clarence Miller, in Acoustical Research, February, 1909, to February, 1910; Instructor in Physics in the Engineering School of Carnegie Institute of Technology, 1913–14; Laboratory Assistant on Thermal Expansion of Solids at the U. S. Bureau of Standards, 1916; Assistant Examiner of Aeronautics at U. S. Patent Office, 1919.

He has been engaged in Patent Law Practice in Chicago since 1919. Mr. Sweet holds membership in Sigma Xi, The American Association for the Advancement of Science, The Philosophical Society of Washington, The Patent Law Association of Chicago, The Chicago Bar Association, The Illinois State Bar Association, The American Bar Association, Phi Beta Kappa, and the Evanston University Club. He is one of the founders of the Midwest Association of Sigma Xi.

DONALD HOWARD SWEET

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